

1061 49
THE

Description *and* Use 76

O F

Four New Instruments,

V I Z.

First. The VARIATION and TIDE INSTRUMENT.

Second. A LUNAR INSTRUMENT for shewing the Places of the Sun and Moon; also for finding the Time of High-Water at any Time and Place, both on Common and New Principles; to which is added, a NAUTICAL POCKET PIECE.

Third. The IMPROVED ANALEMMA, for solving the Common Problems of the Celestial Globe.

Fourth. The PANORGANON for solving those of the Terrestrial Globe; being very useful to young Students in Geography.

By BENJAMIN DONN,

Master of the MATHEMATICAL
ACADEMY, *Bristol.*

Price SIX - PENCE.

London: Sold by Messrs. MOUNT and PAGE, on Tower-Hill; B. LAW, in Ave-Mary-Lane; J. JOHNSON, St. Paul's Church-Yard; R. SAYER, in Fleet-street; Messrs. HEATH and WING, in the Strand; and by the Author at Bristol. Of whom may be had, The Instruments.

1772?

AT the MATHEMATICAL ACADEMY, in the LIBRARY
House, in KING-STREET, Bristol: YOUNG GEN-
TLEMEN are boarded, and taught WRITING, ARITHME-
TIC, BOOK-KEEPING, NAVIGATION. and GEOGRA-
PHY.—Also the ELEMENTS, of ALGEBRA, ALTIMETRY
ARCHITECTURE, ASTRONOMY, CHANCES, CONICS, DE-
CIMALS, DIALLING, FLUXIONS, FORTIFICATION, GAUG-
ING, GEOMETRY, GUNNERY, HYDRAULICS, HYDROSTA-
TICS, LEVELLING, MECHANICS, MENSURATION, OPTIC
PERSPECTIVE, PNEUMATICS, SHIP BUILDING, SURVEY-
ING, TRIGONOMETRY, Plane and Spherical, with the Use
Mathematical and Philosophical Instruments, in a rational and
expeditious Manner, according to the New Improvement
Also Courses of Experimental Philosophy read on reasonable
Terms.

By B. D O N N.

PROPOSALS at large may be had at the ACADEMY; where
are sold, by the AUTHOR, 1st. Essays on Arithmetic, Vulgar
and Decimal, pr. 6s.—2. The Accountant and Geometrical
pr. 6s.—3. Young Shopkeepers, Stewards, and Factors Com-
panion, pr. 1s. 6d.—The Variation and Tide Instrument im-
proved, pr. 2s.—The Lunar Instrument for shewing the Place
of the Sun and Moon, and Time of High-water, pr. 2s.—
6. The Improved Analemma, pr. 3s. 6d. and 7. The Panor-
mon for solving the usual Problems of the Globes, pr. 5s.—
8. A Sinical Quadrant, pr. 1s.—9. the Navigation Scale im-
proved, pr. 4s.—10. Nautical Pocket Piece, pr. 6d.—11.
Map of the Country 11 Miles round Bristol, pr. 1l. 7s. past
on Canvas and coloured. Also sold Sea Books, Maps, Chart
Quadrants, and other Mathematical Instruments.

*** The Author's Map of the County of Devon, which ob-
tained the First Premium, of 100l. of the Society of Arts, &
pr. 2l. 7s. is sold only at Exeter.





To the **R E A D E R.**

HAVING found by long Experience in teaching that the Variation Instrument is of great Use, in conveying just Ideas of the Nature of finding the Variation of the Compass, and readily shewing how to allow for the Variation, Lee-way, &c. In the Year, 1766, I was inclined to make some Improvements therein for the Use of my Pupils; and published it under the Title of *The Variation and Tide Instrument improved*. Since which, having constructed *A Lunar Instrument, Improved Analemma, and Panorganon*; it seems now necessary to collect the Uses of these several Instruments together, that they may be useful to young Students in General.

B. D O N N.

**The Use of the VARIATION and TIDE
INSTRUMENT *improved*.**

THE Instrument as now improved, consists of three circular Plates. 1. The largest or under Plate contains two annular or circular Spaces, marked A and B, representing the Horizon or immoveable Compass. A, contains the Points of the Compass, with their Subdivisions into Halves and Quarters. B. each Quarter of the Compass divided into 90 Degrees.

2. The middle Plate, contains 3 circular Spaces, distinguished by C, D, and E. — C. is divided into Degrees; and D, into Points and Quarter Points, representing the magnetical or common moveable Compass. E. is a Circle of Hours and Quarters.

3. The upper or lesser Circle. This contains two circular Spaces F. and G. — G, is divided into $29\frac{1}{2}$ equal Parts, representing the Moon's Age, for finding the Moon's Southing and Time of High-water, according to mean Motion. — F, is divided into unequal

equal Parts, denoting Days and Quarters of Days, before and after Full, Change, and Quarter Days of the Moon, for the more accurately finding the Time of High-water.

PROBLEM I. *To find the Variation of the Compass.*

Having set the Sun by your Compass, and noted the Bearing, called, if the Sun be rising or setting, the magnetical Amplitude; but if taken at any other Time of the Day the magnetical Azimuth: Observe this Rule. Lay the String on the true Amplitude or Azimuth in the circular Space B, and turn the moveable Compass about, until the magnetical Amplitude or Azimuth on the circular Space C, comes under the String, then will the North Point of the moveable Compass shew the Variation, on the circular Space B, of the immoveable.

EXAMPLE. Suppose at Sea, when the Sun was S. 30° E. by the Compass, I found it was S. 50° E. by Astronomy; what is the Variation?

Here laying the String on S 50° E. on the Space B, and moving the Middle Plate about, when S. 30° E. on C, comes under the String, you will find the North Point of this Plate, point to N. 20 Degrees West on the large Plate; or in other Words, the Compass has 20 Degrees West Variation.

PROBLEM II. *Knowing the Variation of the Compass, to correct the Course steered by the Compass.*

Set the North Point on the middle Plate, to the Variation on the large Plate; then laying the String over the Course steered by the Compass on the middle Plate, it will, if extended, cut the true Course on the large Plate.

EXAMPLE I. In a Place where the Variation is 3 Quarters of a Point Easterly, a Ship sails E. N. E. what is the Course made good, she making no Lee-Way? Lay

Lay the String on N. 3 Quarters East, on the large Plate, then turning the middle Plate about, until its North Point comes under the String, keep it there; and laying the String over E. N. E. on the Space D, it will cut E. N. E. 3 Quarters East on the Space A; the true Course required.

EXAMPLE 2. The Variation of the Compass being 1 Point Westerly, the Lee-way 1 $\frac{1}{2}$ Point, and the Wind at S. W. a Ship steers by Compass S. S. E. What is the Course made good? —

First, to allow the Lee-way; laying the String on the S. S. E. Point, representing the Course steered, it is plain, the Wind blowing S. W. must drive the Ship towards the East, therefore counting 1 $\frac{1}{2}$ Point Eastward from S. S. E. brings the Course made good if no Variation, to be S. E. b. S. $\frac{1}{2}$ E. Then 1 Point West Variation being allowed on this, by the above Rule, will bring out the true Course S. E. $\frac{1}{2}$ E.

PROBLEM III. *The true Course from any Place to another being found by a Chart or otherwise, to find what Compass Course a Ship must steer to make that Course good, the Variation and Lee-way being given.*

Let the Example be the Reverse of the last, viz. suppose the Variation of the Compass 1 Point Westerly, the Wind at S. W. and the Lee-way 1 $\frac{1}{2}$ Point; required what Course the Ship must steer by the Compass, to make good a S. E. $\frac{1}{2}$ E. Course?

First, Set the North-Point of the middle Plate to the Variation on the large Plate; then laying the String on the true Course S. E. $\frac{1}{2}$ E. on the Space A, it will cut on the Space D, S. E. b. S. $\frac{1}{2}$ East; which is the Compass Course answering to the true S. E. $\frac{1}{2}$ E. and would be that required, if there was no Lee-way: But as the Ship makes 1 $\frac{1}{2}$ Point Lee-way, lay the String on S. E. b. S. $\frac{1}{2}$ E. and to make that Course good, she must lie up 1 $\frac{1}{2}$ Point nearer the Wind, therefore the Ship must steer S. S. E. Thus

Thus much is sufficient to shew the Usefulness of that Part of the Instrument, which relates to the Variation and Lee-way. As to that which concerns the Tides, its Use being the same as in the *Lunar Instrument*, we shall refer to the Use of that Instrument, which will be given next in Order.

The Use of the Lunar Instrument.

IN the Year 1766, I published THE VARIATION AND TIDE INSTRUMENT IMPROVED: Having then made but few Observations on the Tides, I built the Construction of that Tide Instrument on the Tables of the celebrated *Abbe de la Caille*; since which Time having made and caused to be made some hundred Observations at Bristol, this Lunar Instrument as far as it relates to the Tides is constructed on these Observations, and will be found more accurate for Bristol, and I hope for other Places also.

This Instrument consists of three Plates for the several Purposes following.

PROBLEM I. *To find the Sun's Place at any Time.*

This is done by Inspection of the middle Plate, for against the Day of the Month is the Sun's Place required. *Et Contra.*

PROBLEM II. *To find the Place of the Moon's ascending or North Node.*

The Place of the Moon's ascending Node is marked on the middle Plate for the Years 1770, 1780, 1790, 1800. Set the Index of the upper Plate to one of these Years, viz. to that which is the nearest preceding the Time you are working for; thus if you are working for any Year from 1771 to 1779 inclusive

five, set it to 1770; then lay the String over the Years and Months elapsed since the Beginning of that Year, on the Space of *Nodes Motion*, and it will cut, on the middle Plate, the Place of the Moon's Node for the given Time.

PROBLEM III. *To find the Moon's Place, both with respect to Latitude and Longitude.*

Lay the String on the North Point of the Compass, (which for Distinction's Sake is assumed to denote the Place of the North Node) then turn the middle Plate about 'till the Place of the Node, found by the last Problem, comes under the String: Keep the middle Plate in this Position. Set the Index of the upper Plate to the Day of the New Moon next preceding the given Time on the middle Plate; then laying the String over the Moon's Age on the upper Plate it will cut on the middle Plate the Sign and Degree of her Place, which is called her Longitude; and at the same Time on the outermost Circle of the under Plate, the Moon's Latitude in Degrees, or her Distance from the Ecliptic either North or South.

PROBLEM IV. *To find the Time of the Moon's Southing.*

Set the Index of the middle* Plate to XII Hours on the under Plate, then against the Moon's Age on the middle Plate, is the Time of her Southing on the under Plate.

PROBLEM V. *To find the Time of High-water at any place by the common Method.*

Set the Index of the middle Plate to the Time of flowing at the given Place, in the Circle of Hours
on

* In applying the Directions, in this and the following Problems to the *Variation and Tide-Instrument*, for Under read Middle, and for Middle read Upper.

on the under Plate; then laying the String over the Moon's Age on the middle Plate, it will cut the Time of High-water on the under Plate.

Note. In all these Problems relating to the Moon, the Time of New Moon is taken from any common Almanack; the Moon's Age is the number of Days elapsed since the preceding New Moon; and the several Answers agreeable to Mean Motion.

Thus for Example. By the Nautical Ephemeris for the Year 1769, on the 28th of June, the Moon was twenty-six Days old, which gives the Time of High-water at Bristol that Day at 4h. 13m. in the Afternoon. But that Day I observed and found it was Highwater at 1h. 12m. so here the Error is no less than 3h. 1m.

PROBLEM VI. *To find the Time of High-water according to the New Principles.*

To illustrate the Method of doing this let us take the preceding Example, viz. for June 28, 1769, in the Afternoon.

By an Almanack or Ephemeris for that Year, the Moon was in her last Quarter the 26th Day 1 in the Morning; from which the 28th Day Noon is distant 1 Day 11 Hours, called the Interval after the last Quarter. The Index of the middle Plate being set to 7h. 4m. the Time of flowing at Bristol, this Interval on the middle Plate will correspond to about 1 o'Clock on the under Plate (disregarding Minutes as of no Consequence at present) this we call the *Estimate Time*, which being for the Afternoon is 28 Days 1 Hour, which gives 1 Day 12 Hours after the last Quarter for the *True Interval*; corresponding to which on the middle Plate (the Plates remaining as before) will be 1h. 15m. for the required Time of High-water; differing only 3 Minutes from the Truth, at the same Time as the common Method erred 3h. 1m. as before observed. The old Method is grounded on Principles entirely false.

But

But this, as it did not throughout that whole Year at Bristol, at a Mean err more than 14 Minutes, is I believe as accurate as so uncertain a Thing as the Tides can be solved, by one general and easy Rule.

By the *Flowing* is meant the Time of Highwater at New or Full Moon at the given Port. We have on this Instrument only engraved a few, viz.

Bideford and Bristol on my own Knowledge; Liverpool which I have deduced from Observations made at that Place by a Friend; London on the Authority of Mr. Phillips, and Dublin Bar on that of Mr. Mollineaux, both taken from the Philosophical Transactions: Portsmouth on that of Mr. Robertson, late Master of the Royal Academy at that Place.

The Flowings at a Number of other Places may be seen in almost every Treatise on Navigation; but as they are in general very inaccurate, I did not choose to give them on the Instrument; but shall from Time to Time add such as may be communicated to me, on proper Authority; and all Informations of that Sort will be gladly received, as will the Latitudes and Longitudes of Places from any Astronomer or ingenious Sea Captain, &c. *Post paid*, and they shall be inserted in my intended Treatise of Navigation, with their Names, If agreeable.

How the Flowing at any Port may be determined, is shewn in the next Problem, viz.

PROBLEM VII. *By observing the Time of High-water any Day, at any Port, to find what Time it is High-water at New and Full Moon, vulgarly called the Flowing.*

By Subtraction, find the Interval of Time between the observed Time of High-water and the nearest Phase of the Moon. Bring that Interval of Time on the middle Plate to correspond to the observed Time of High-water on the under Plate; then will the New or Full Moon on the middle Plate, point out the Flowing on the under Plate.

EXAMPLE.

EXAMPLE. April the 25th, 1766, it was High-Water at Bristol, at 7^h 40^m in the Evening; required the Flowing.

	Day.	h	m
Solution. From the Time observed	25	7	40
Subtract Time of Full-Moon	24	12	0
Remains Interval of Time	} 0 19 40		
after Full-Moon			

That is, nearly 20 Hours after the Full-Noon.

Bring that 20^h to correspond to 7^h 40^m and the New or Full Moon, will point out 7^h 4^m for the required Time of Flowing.

In Order to be accurate, it may be proper to hint, that your Watch must be first set to apparent Time by a good Sun Dial or Astronomical Observation.—If Opportunity will permit, to be more exact, Observations should be made at several New and Full Moons, to find the Flowing, and a Mean taken of the Results, for the true Time.

Would our capable Navigators exert their Abilities in carefully making proper Observations of the Latitudes and Longitudes, of the principal Places, Capes, or Head Lands, Variation and Tides, and communicate them, with the Numbers as taken by their Quadrants, &c. to be examined and published for the Benefit of all in General, I am satisfied we should soon find, that the Art of Navigation is not so very imperfect as some Persons think. But whilst too many of our Navigators, though allowed to be more capable than those of any other Nation, are so indolent, pardon the Expression, as not to lend their helping Hand, but to let our Charts and Tables still retain their numberless Errors, what Improvement can be hoped for?—I must therefore beg Leave once more to exhort every Person properly qualified, to exert himself for the Improvement of the Art, and the Honour

Honour of our Nation. I have only to add, my Assistance shall not be wanting, as far as my Abilities and Opportunities will permit.

N. B. The Almanacks being generally calculated for London, if you are in a Place whose Longitude differs considerably from London, it will be proper to reduce the Time of the nearest Phase of the Moon to the Meridian you are in, by subtracting the Difference of Longitude in Time, if you are in West Longitude, or adding if in East Longitude.

As to the Nautical Pocket Piece on the upper Plate, it may be had separate on Card Paper, for the Pocket, &c. and as it contains the natural Sines for every Degree and Point of the Compass, a Day's Work at Sea, or a common Problem in Trigonometry may be readily solved, by a Pen or Piece of Chalk only, in the Absence of Tables, as will be easily understood by such Persons as are acquainted with these Subjects; but for others it would take up more Room and Time than can at present be spared. This is intended to be particularly treated of in our Treatise of Navigation, now compiling.

* * On the Back of the Card Paper Pocket Piece, are printed the Rules necessary for solving the Common Cases in Trigonometry and Navigation, viz.

As S of any Angle : its opp. Side :: S.
of any other Angle, : its opp. Side
and the Contrary

Square Root of Sums of the Squares of
the two Legs equal to Hyp. or Dist.

Square Root of the Product of Sum and
Diff. of Hyp. (or Dist.) and one Leg equal
to the other Leg.

Usual Canons in working a Day's Work
at Sea are,—As R : Dist :: S Course :
Dep. and :: S C Course : Diff. Lat.—
As S C Mid. Lat. : Dep. :: R : diff. Long.

To find Sun's Amplitude.—As S C Lat.
: S Sun's Dec. :: R : S Sun's Ampd.

To all L O V E R S of
Mathematical Learning.

MR. D O N N begs Leave to acquaint them, that he is far advanced in Writing *An Epitome of NAVIGATION*, containing the Elements with their Application. Including as much of Geometry, Trigonometry and Astronomy as is absolutely necessary for understanding the Practice. Also a more complete Set of Tables than is to be found in any other Book on the Subject. The whole done in a Manner which 'tis supposed will equally serve the Purpose of the Master and Pupil. This he proposes to publish on the following Terms, as soon as a sufficient Number of Subscribers have sent him their Names.

Conditions 1. That a Number be published the 1st of every Month, pr. *Six-pence*, containing 32 Pages, (each Plate being accounted equal to 8 Pages) which is as much as can be afforded in Mathematical Periodical Publications, the Subscribers being fewer and the Expence greater than in most other Subjects.

2. The Whole shall be comprised in 2 Volumes Octavo.

3. A List of Subscribers to be printed as *Encouragers* of useful Learning.

* * * The Author, if he could have 300 Subscribers, has also an Intention of attempting to make a more accurate Map or Chart of the whole known World, (on Wright's Projection) than any hitherto published; on 12 Sheets of Imperial Paper, at 2 *Guineas* each: One to be paid at subscribing, the other on Delivery of the Map.

Letters, *Post paid*, directed to BENJAMIN DONN, in Bristol, from those who intend to encourage either the Publication of the Treatise on Navigation, or the Chart, will be gladly received. As will also any Improvements, which shall be inserted with the Names of the ingenious Contributors, if agreeable.

Mathematical Academy, Bristol,
March 1st, 1771.





USE OF THE

* IMPROVED ANALEMMA.

IT is well known to Masters of Academies who teach Geography and the Use of the Globes, to Youths, whose Parents are not inclined to purchase a Pair of Globes, that after some Time, for want of Opportunity to practise, great Part of what they have learnt, slips their Memory. I am therefore inclined to think, that the Analemma now offered to the Public will be acceptable, as it will in a great Measure supply the Want of a Celestial Globe, as a common Map of the World does in some Degree, that of the Terrestrial.

2. In the Year 1721 my Father (GEORGE DONN) then Teacher of Practical Mathematics at *Bideford, Devon*, engraved an Analemma on Brass, for his own Use, particularly constructed to solve Problems concerning the Sun; which to render more generally useful, I have now adapted to work the usual Problems relating to the Planets, Moon, and Stars, as well as those of the Sun.

3. The moveable Circle or what is commonly called the *Analemma*, is an orthographic Projection of the Sphere on the Plane of the Meridian.

4. The dotted Line which passes through the Center is the *Equinoctial*, the Lines parallel to it are
R Parallels

* Sold by the Author, B. DONN, in Bristol;—also by Messrs. HEATH and WING, Mathematical Instrument-Makers in the Strand; B. LAW, in Ave-mary-lane; and G. KEARSLEY, on Ludgate Hill, (Bookfellers) London,——Price 3s. 6d.

Parallels of Declination ; and for the readier counting, every 5th Degree is engraved stronger than the others

5. The Line which passes thro' the Center and is perpendicular to the Equinoctial is the *Axis* ; one End of which marked with a Fleur-de-Lis is the *North Pole*, as the other End marked S, is the South Pole.

6. The dotted Parallel of Declination $23^{\circ} \frac{1}{2}$ North of the Equinoctial is the *Tropic of Cancer*, as is that $23^{\circ} \frac{1}{2}$ South of the Equinoctial the *Tropic of Capricorn*.

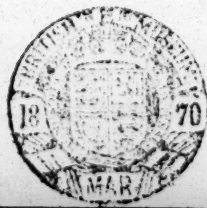
7. The dotted Parallel $66^{\circ} \frac{1}{2}$ North of the Equinoctial is called the *Arctic* or Northern *Polar Circle* ; that in the South, at the same Distance from the Equinoctial, is the *Antarctic* or Southern *Polar Circle*.

8. The dotted Line passing thro' the Center in an oblique Position making an Angle of $23^{\circ} \frac{1}{2}$ with the Equinoctial is the *Ecliptic* ; it is divided by little Lines (") into every 5 Degrees, and subdivided into Degrees by Dots (.)

On each Side of it, at 8 Degrees Distance, is drawn a parallel Line, and the Space contained between these Lines is called the *Zodiac*, in which the *Planets* are always found.

9. The strong elliptic Lines, are *Hour Circles* ; the less strong *Half Hours* ; and those dotted are *Quarters of Hours*.

10. The large Plate contains the following Particulars, besides the *Meridians* and *Prime Vertical*, the *Horizon* S. N. which is divided into Degrees counted from the East or West Point towards the North and South, for finding the Amplitude of the Sun or Star ; and under these Degrees, into Points and Quarter Points of the Compass, counted from the North or South towards the East or West, to shew readily on what Point of the Compass the Sun or Star rises or sets, &c. And to know the corresponding Point of the Compass, in the Right-Hand upper Corner



Corner is engraved a Compass, for such Youths as have not learnt the Sea Compass.

11. In the same Corner is * R. A.—⊙ R. A. or
 * R. A.+24ⁿ—⊙ R. A.
 = * Southing.

which is to be thus read, The Stars Right Ascension *Minus* (or less) the Sun's Right Ascension: Or the Stars Right Ascension *Plus* (or more) 24 Hours *Minus* the Sun's Right Ascension is equal to the Stars Southing. The Use of this will be explained hereafter.

12. Under the Horizon on the Left Hand is a Calendar for our Summer, and on the Right another for our Winter half Year, containing the Days of the Month, Sun's Right Ascension, Place and Declination corresponding thereto, which we shall have Occasion to explain more particularly in the Problems.

13. In the Middle between the Calendars is a Table shewing the Right Ascension and Declination of the Principal Stars; which being calculated for some Years hence, will be sufficiently accurate for many Years to come.

14. PROBLEM I. The Day of the Month being given to find the Sun's Place in the Ecliptic. This is done by Inspection of the Calendar only.

EXAMPLE. Thus it will be seen that the 20th of March the Sun enters *Aries*, the 20th of April *Taurus*, May the 21st *Gemini*, the 21st of June *Cancer*, the 23d of July *Leo*, the 23d of August *Virgo*, September 22d *Libra*, October 23d *Scorpio*, November 22d *Sagittarius*, December 21st *Capricornus*, January 20th *Aquarius*, February 18th *Pisces*.

N. B. The Line for the Sun's Place is marked ⊙ P and is divided into every 5 Degrees by Dashes (—) and subdivided into Degrees by Dots (..).

15. PROBLEM II. By the Sun's Place in the Ecliptic to find the Day of the Month.

This

This being only the Reverse of the former needs no particular Explanation.

16. PROBLEM III. By the Day of the Month to find the Sun's Declination. This may also be found by barely inspecting the Calendar. Thus for Example January 20th against that Day of the Month in the Column D. you will find the Sun's Declination 20 Degrees South.

But if the young Student is inclined to solve this Problem on the Analemma, it may be done thus. Bring the Equinoctial to the Horizon and the Southern Part of the Ecliptic above the Horizon, then looking for the Sun's Place corresponding to the Day of the Month (which in the present Example is 0° Aquarius) observe what Parallel of Declination crosses that Place, and we shall have the Declination, in the present Example 20° as afore found.

17. PROBLEM IV. By the Sun's Declination to find the Day of the Month.

This is also readily done by Inspection of the Calendar.

Let the Example be the Reverse of the last, viz. the Sun's Declination being 20 Degrees South, what is the Day of the Month? Answer, it appears by the Calendar that it may be either the 20th Day of January or the 21st Day of November.

If it be required to solve this Example on the Analemma, bring the Southern Part of the Ecliptic above the Horizon, and the Equinoctial in the Horizon, then will the Parallel of Declination, in our Example the 20th Degree, cross the Ecliptic in 0° of *Sagittarius*, and 0° of *Aquarius*, the two Places of the Ecliptic in which the Sun has that Declination. Hence by Problem II. the Days are as above.

18. PROBLEM V. To rectify the Analemma for any particular Place.

This is only to bring the Pole to the Latitude of the

the Place, the North Pole to the North Meridian if the Place is in North Latitude; but the South Pole to the South Meridian for South Latitude.

19. PROBLEM VI. To find the Sun's Amplitude, or on what Point of the Compass the Sun rises and sets at any given Place on any given Day.

Rectify the Analemma by the last Problem; and by the Day of the Month find the Sun's Declination, by Inspection of the Calendar as shewn in Problem IIIId. Then will the Parallel of that Declination cut the Sun's Amplitude on the Horizon.

EXAMPLE. On what Point of the Compass does the Sun rise and set at London (Latitude $51^{\circ} \frac{1}{2}$ North) the 20th of June? Working as above directed it will be found that the Sun rises E. 40° N. and sets W. 40° N. or rises nearly N. $4 \frac{1}{4}$ Points E. and sets N. $4 \frac{1}{4}$ W. which answer to N. E. $\frac{1}{4}$ E. and N. W. $\frac{1}{4}$ W.

20. PROBLEM VII. To find the Time of Sun Rising and Setting, Length of the Day and Night at any given Place, whose Lat. does not exceed $66^{\circ} \frac{1}{2}$.

Rectify the Analemma, and find the Sun's Declination for the given Day, then observe what Hour Circle cuts the Horizon, and it will shew how much the Sun rises before or sets after Noon.

N. B. In South Latitude the Hour Circles on the Analemma are each numbered from Midnight; and so shew the Time of Sun rising, as the Numeral Hours in North Latitude do the Time of Sun setting.

EXAMPLE. On June 20th at London Latitude $51^{\circ} \frac{1}{2}$ the Sun's Declination being $23^{\circ} \frac{1}{2}$ North, it will be found that the Sun rises about $8^h \frac{1}{4}$ before Noon or 3 Quarters after 3 in the Morning; and sets a Quarter after 8.

Hence the Length of the Day being equal to double the Sun's setting is equal to $16^h \frac{1}{2}$, and as the Sun's Declination in the Example is the greatest, it shews that $16^h \frac{1}{2}$ is the longest Day at that Place.

21. PROBLEM VIII. To find the length of the longest Day at any Place in the Polar Circles.

To illustrate this let the Place be Hacluit's Head-land in Greenland, Lat. 80° North.

Rectify the Analemma, then you will readily see that when the Sun comes to 10° Declination (equal to the Complement of Latitude of the Place) the Sun would 12 Hours after Noon come to the Horizon in the North but not set; this corresponds to the 16th of April; from which Time the Sun being going to the Northward continues above the Horizon till it returns to 10° North Declination again, which in the Calendar answers to the 27th of *August*. Hence it appears that it is *all Day* at that Place, from the 16th of *April* to the 27th of *August*.

In the same Manner it will be found that at the Poles or in 90° of Latitude either North or South, there is but one Day and one Night in a whole Year.

22. PROBLEM IX. To find the Sun's Altitude at a given Place, at any given Day and Hour.

This admits of 3 Cases: —

First. When the Meridian Altitude is required, rectify the Analemma, then will the Parallel of Declination cut the Meridian in the Altitude required.

EXAMPLE. The Sun's Meridian Altitude at Noon at London the 1st of May, will be found to be $53^{\circ} \frac{1}{2}$.

Case 2. When the Sun's Altitude is required at the Time it is East or West.

The Analemma being rectified, observe what Degree of the Prime Vertical is cut by the Parallel of the Sun's Declination, and that will be the required Altitude.

EXAMPLE. On the above Day it will be found to be $19^{\circ} \frac{1}{4}$.

Case 3. When the Altitude is required at any other Time of the Day.

Rectify the Instrument and observe where the Parallel of Declination intersects the given Hour Circle; then placing one Leg of a Pair of Compasses on that Point, extend the other Leg to take the nearest Distance to the Horizon; then will

will that Distance measured on the Prime Vertical give the Altitude required.

EXAMPLE. At London Latitude $51^{\circ} \frac{1}{2}$ N. the 21st of June at 3 in the Afternoon, the Sun's Altitude will be found to be $45^{\circ} \frac{1}{2}$.

23. PROBLEM X. Given the Latitude of the Place, Day of the Month and Altitude of the Sun (taken by a Quadrant or other Instrument) to find the Time of the Day.

Rectify the Analemma, then lay a String across both Meridians so that it may cut the Sun's Altitude on both Meridians; then, where the String crosses the Parallel of Declination, that is the Place of the Sun, and consequently the Hour Circle passing through that Place, will shew the Time required.

Let the Example be the reverse of the last Problem.

24. PROBLEM XI. To find the Sun's Depression at Midnight.

Rectify the Analemma, and as many Degrees as the Sun is below the Horizon, so many Degrees will the Parallel of equal Declination, but with contrary Name, be above the Horizon at the other Meridian.

EXAMPLE. In Latitude $51^{\circ} \frac{1}{2}$ North, on the 15th of April, it will be found that the Sun is $28^{\circ} \frac{1}{2}$ below the Horizon (in the North).

25. PROBLEM XII. To find the Beginning, and Duration of Twilight.

Twilight begins and ends when the Sun is 18° below the Horizon.

Rectify the Analemma, then laying a String across 18° of Altitude on both Meridians, observe where it intersects a Parallel of Declination equal to that of the Sun, but with opposite Name; and the Hour Circle passing through that Place will shew the Time of the Beginning of Twilight, counted from Midnight.

Thus for Example, it will be found that Twilight begins or Day breaks the 1st of October at London
at

at $\frac{1}{4}$ after 4 in the Morning, and the Sun rises that Day at $6^h \frac{1}{4}$, so that the Duration of Twilight in the Morning is 2 Hours, and it being the same in the Evening after Sun set, will be in all that Day 4 Hours, which added to the Length of Day $11^h \frac{1}{2}$ gives the Time from Day-break to dark Night $15^h \frac{1}{2}$.

Note, From the End of May to the Middle of July, there is no dark Night, in the Latitude of London.

26. PROBLEM XIII. To find what Day of the Year the Sun will be vertical to a given Place in the Torrid Zone.

As the Latitude is counted from the Equator on the Terrestrial Globe the same Manner as the Declination is counted from the Equinoctial; we have nothing to do but to find on what Days the Sun's Declination is equal to the Latitude of the Place, and of the same Name.

EXAMPLE. Thus at Jamaica (Lat. $17^\circ \frac{1}{4}$ North) it will be found the Sun is vertical or passes directly over Head at that Place the 10th of May and 2d of August.

Hence it appears that those Places which lie between the Tropics may be said to have two Summers in a Year.

27. PROBLEM XIV. Given the Latitude of the Place Day of the Month, and Altitude of the Sun taken (by a Quadrant) in the Fore or Afternoon, to find the Sun's Azimuth.

Rectify the Analemma and find the Sun's Declination; then laying the fiducial Edge of a Ruler to cut the Sun's Altitude on both Meridians, observe where the Edge of the Ruler cuts the Parallel of Declination, for that is the Sun's Place; against which on the Edge of the Ruler make a Mark with a Pen or Pencil, also where the Ruler crosses the Prime-Vertical; then taking off the Ruler, bring the Pole to the Zenith, and the Hour Circles become Azimuth Circles. Then, placing the Ruler

as before, which may be easily done by the Sun's Altitude and the Marks above directed to be made, observe which Hour (now Azimuth) Circle passes by the Sun's Place marked on the Ruler, then that Hour (or Azimuth) Circle will on the Horizon shew the required Azimuth.

EXAMPLE. At London in Lat. $51^{\circ} \frac{1}{2}$ N. the 21st of August, when the Sun's Altitude is $41^{\circ} \frac{1}{2}$ in the Forenoon, his Azimuth is S. 57° E. which is nearly 5 Points from the South towards the E. or S. E. by E. and in the Afternoon when the Sun has the same Altitude it is S. W. by W.

Note, This may also be solved by Means of the Horn hinted at in the Scholium to the next Problem.

28. PROBLEM XV. To find the Sun's Azimuth at any given Day and Hour at any Place.

This admits of 3 Cases.

Case 1st. At Noon or Midnight, the Sun is on the Meridian, and so must be either North or South.

Case 2^d. To find the Sun's Azimuth at any other Time of the Day.

Here, as the Azimuth Circles could only be laid down on the Moveable Circle for a particular Latitude, that Defect may be thus supplied.

Having rectified the Analemma and found the Sun's Declination: The Place where the Parallel of Declination cuts the given Hour Circle, is the Place of the Sun for that Time. With a Pair of Compasses take the nearest Distance from that Place to the Horizon, which measured on the Prime-Vertical, will shew the Sun's Altitude at that Time. This done, lay the fiducial Edge of a Ruler to cut each Meridian in the Sun's Altitude, then observe where the Ruler intersects the Place of the Sun above found, and the Prime-Vertical; against each of these Places make a Mark, with a Pen or Pencil on the Edge of the Ruler.

Now turn the moveable Circle 'till one of the Poles comes in the Zenith, then may the Hour Circles

Circles be looked on as Azimuth Circles. Then the Ruler by the Marks made on its Edge, may be easily placed in its former Position; which being done, observe what Hour Circle (now Azimuth Circle) intersects the Ruler at the Mark made for the Sun's Place, and carrying your Eye along that Circle 'till you come to the Horizon, you'll see the Azimuth required.

EXAMPLE. At London, the 21st of June at 3 o'Clock in the Afternoon, it will be found, that the Sun is about 6 Points from the South towards the West, that is, about W. S. W.

29. SCHOLIUM. If the Azimuth Circles be drawn on a Quarter of a Circle, made of clear Horn, then as the Hour Circles, &c. can be seen thro', the Azimuth may be found by Inspection. Such a Horn may be made for Six-pence; and if requested, may be had with the Instrument at that Price.

PROBLEM XVI. Given the Latitude of the Place and Day of the Month to find on what Time of the Day the Sun will be on a given Azimuth.

Rectify the Analemma, and find the Sun's Declination, then lay the Horn so that the Zenith of the Horn may be in the Zenith of the Instrument, that the Line drawn on it from the Zenith may lie on the Prime-Vertical, and that the Line on it perpendicular thereto, may lie in the Horizon, &c. then we have only to observe where the given Azimuth crosses the Parallel of the Sun's Declination, and that will be the Place where the Sun is at that Time; and consequently, the Hour Circle passing by that Place, will be that required.

The Example may be the Reverse of that in Problem XV.

Of the STARS.

30. PROBLEM XVII. To find the Time of a Star's coming on the Meridian (or when its Altitude

is the greatest possible for that Day) vulgarly called the Southing.

We have already given the Rule in Art. 11.

EXAMPLE. What Time is *Arcturus* South, the 17th of May.

In the Table of Stars on the Instrument,
the Stars Right Ascension is - - 14^h 5'

The Sun's R. A. by Inspection of the
Column R. A. of the Calendar is - 3 38

Remains 10 27

That is, *Arcturus* is South that Night at 27 Minutes after 10.

31. SCHOLIUM The Manner of Working for the Stars, Moon, Planets, &c. is so near that of the Sun, that it seems only necessary to hint, that the Declination of the Stars being taken out of the Table of Stars, and of the Moon or Planets from an Ephemeris or Annual Almanack, work for the Stars, &c. in the same Manner as has been shewn in the Problems for the Sun; only it must be noted, that the Time found by such Operation must not be considered as so many Hours before or after Noon; but so many Hours before or after the Southing of the Star, Moon, or Planet.

Thus for Example, if it be required to find the Time of *Arcturus* Rising and Setting the 10th of May at London.

By rectifying the Analemma, the Declination of the Star being 20° 24' N. we shall see by inspection that its semidiurnal Arc, or Time of the Stars setting after its Southing is 7^h 50'.

The

The Time of Southing being $10^h \ 27'$
 Subtract and add semidiurnal Arc $\left. \begin{array}{r} - \\ - \\ - \end{array} \right\} 7 \ 50$

Gives Time of Rising $- \ 2 \ 37$ after Noon.

And the Star sets after Noon $\left. \begin{array}{r} - \\ - \\ - \end{array} \right\} 18 \ 17$
 of 17th Day $- \ 12$
 Subtract $\underline{\hspace{1cm}}$

Gives Star's Setting the next Morning at $\left. \begin{array}{r} - \\ - \\ - \end{array} \right\} 6 \ 17$

Many other Problems might have been given, but if the Reader rightly understands what is already delivered, he will not find it difficult to solve more, without any further Assistance.

F I N I S.

AT the MATHEMATICAL ACADEMY, in the LIBRARY-HOUSE, in KING STREET, Bristol: YOUNG GENTLEMEN are boarded; and taught WRITING, ARITHMETIC, BOOK-KEEPING, NAVIGATION, and GEOGRAPHY:—Also the ELEMENTS of ALGEBRA, ALTIMETRY, ARCHITECTURE, ASTRONOMY, CHANCES, CONICS, DECIMALS, DIALING, FLUXIONS, FORTIFICATION, GAUGING, GEOMETRY, GUNNERY, HYDRAULICS, HYDROSTATICS, LEVELLING, MECHANICS, MENSURATION, OPTICS, PERSPECTIVE, PNEUMATICS, SHIP-BUILDING, SURVEYING, TRIGONOMETRY, Plane and Spherical; with the Use of Mathematical and Philosophical Instruments, in a rational and expeditious Manner, according to the New Improvements. — Also, Courses of Experimental Philosophy read on reasonable Terms.

By *B. D O N N.*

PROPOSALS at large may be had at the ACADEMY, where are sold, by the AUTHOR, 1st. Essays on Arithmetic, Vulgar and Decimal, pr. 6s.—2. The Accountant and Geometrician, pr. 6s.—3. The Navigation Scale improved, pr. 4s.—4. The Variation and Tide Instrument improved, pr. 2s. 6d.—5. A Map of the Country 11 Miles round Bristol, pr. 1l. 7s. fitted up.—6. Young Shopkeepers, Stewards, and Factors Companion, pr. 1s. 6d.—7. Epitome of Philosophical Lectures, pr. 2s. 6d.—8. The Improved Analemma, for the Use of Schools, by which may be solved the Common Problems of the Celestial Globe, pr. 3s. 6d.—** Preparing for the Press a Treatise on Navigation.



THE
USE OF THE
* PANORGANON,
FOR SOLVING THE
COMMON PROBLEMS
OF THE
TERRESTRIAL GLOBE.

1. **A**S but few Parents will be at the Expence of a Pair of Globes, I found it necessary to publish, a few Months since, for the Use of my Geographical Pupils, AN IMPROVED ANALEMMA, Price 3s. 6d. by which may be solved the Common Problems of the Celestial Globe. As to the Terrestrial, it was then only observed, that a common Map of the World does in some Degree supply its Want : But as that is in a very imperfect Degree, some Gentlemen expressed a Wish, that I could invent an Instrument which might solve the most valuable Problems of the Terrestrial, as well as the *Analemma* does those of the Celestial. This, gave rise to the *Panorganon*, now presented to the Public, and which with the *Analemma*, it is hoped the Masters of Academies will find useful to their Pupils.

A

2. The

* Price 5s. plain, or 6s. coloured Sold by the Author B. DONN, at Bristol; also by Messrs. Mount, and Page, on Tower-Hill; B. Law, in Ave-mary-Lane; J. Johnson, St. Paul's Church-yard; R. Sayer, in Fleet-street; and Messrs. Heath and Wing, in the Strand, London.

2. The PANORGANON consists of two principal Parts, one is for the Northern, the other for the Southern Hemisphere.

3. Each Part consists of two Plates, upper and under. The under or circular Plate contains the principal Places, in its respective Hemisphere, laid down according to their Latitudes and Longitudes, with the new Discoveries, being delineated on Purpose, and not a Copy of any other Map.

4. Each Hemisphere is an *Orthographic Projection*, on the Plane of the *Equator*; by which Means the *Pole* is in the Center, and the *Meridians* become right Lines, as they are right Circles on the Terrestrial Globe.

5. The *Parallels of Latitude* in this Projection, are concentric Circles about the Pole, and manifestly Parallel to the Equator, as they are on the Globe.

6. It may perhaps be objected, that the Degrees of Latitude diminish very much towards the Equator, and consequently the Places near it will be much shorter from North to South, than they are with respect to their Breadth, from East to West on the Globe. In Answer to this, it is well known to those who are well acquainted with the Subject, that it is impossible on any Principle of Perspective, to observe the apparent proportional Magnitudes in a Delineation on Paper. That we must judge of their Length and Breadth, by the Number of Degrees they extend, and not from their apparent Magnitude.

7. If the *Stereographic Projection* had been made use of, the Degrees would have been shorter near the Pole, and wider as they approached the Equator.

8. There is an arbitrary Projection sometimes used, called the *Globular Projection*, not founded on any Principle of Perspective; but to make the Places appear of nearly the same apparent Magnitude, as they are on the Globe; and if it had been designed only to have made a Picture, this would have been preferred.

9. The



9. The Preference has been given to the first or Orthographic Projection, in constructing the *Panor-ganon*; principally, because the Degrees of Longitude, or Distance of Meridians decrease in this, as they approach the Pole, in the same Proportion, as they really do on the Globe, which is peculiar to this Projection, and very naturally explains the Nature of Parallel Sailing in Navigation. I have said thus much to take off the Cavils of some ignorant Critics; who not seeing the Advantages of this Projection, might possibly be glad to point out its Defects. However, I think it not worth while to spend any more Time on this Head; but proceed with the Description.

10. The *Equator* is divided into 180 Degrees of East, and 180 Degrees of West Longitude, counted from London according to the English Method.

11. The upper or large Plate contains, first a Circle of 24 Hours, viz. Twelve Morning and Twelve Evening Hours, supplying the Place of the Hour Circle on the Globes, but more accurate as it is larger, and divided into every five Minutes of Time; so that the Difference of Time between two Places, whose Longitudes are accurately known, may by it be readily shewn to a Minute or two of Time.

The outermost Circle of the upper Plate, contains Longitude counted all round the World East, as the French, and other Foreigners do. Its Use will be shewn in its proper Place: In the upper Corners of the large Plates, are Scales for shewing by Inspection the Sun's Declination, answering to any Day of the Month, *et contra*.

At the Bottom of the upper Plate of the Northern Hemisphere is a Scale made in Form of a Carpenter's Square, marked A C B, for finding the Distances of Places, &c. And a Quarter Part of a Compass for finding the Courses, which as it is there made, serves instead of a whole Compass.

In order to be as Compendious as may be, we suppose our Reader to know what is meant by Latitude

tude and Longitude, and other common Terms use in Geography; but if he is not, he will find them explained in our Epitome of Philosophy, Geography and the Use of the Globes, &c. Price 2s. 9d. stitched.

We have constructed the Panorganon in such Manner that the common Problems may be solved by it, in nearly the same Manner as they are on the Terrestrial Globe.

12. Thus. PROBLEM I. *By the Latitude and Longitude of a Place to find it on the Instrument.*

Solution. Find the Longitude of the Place on the Equator, bring that Degree of the Equator, to the graduated Edge of the General Meridian, then under the Degree of Latitude, counted on the General Meridian, you will find the required Place.

N. B. The General Meridian is strictly speaking the graduated Edge itself, viz. the right Line passing from XII at Noon, to the Pole or Center of the upper Plate.*

13. PROBLEM II. *To find the Latitude and Longitude of any Place on the Hemispheres.*

Bring the given Place to the General Meridian then the Degree directly over the Place will shew the Latitude; and where the general Meridian crosses the Equator will be the Longitude required.

EXAMPLE I. What is the Latitude and Longitude of the Cape of Good Hope, in the Southern Hemisphere.

ANSWER. Latitude 34° S. and Longitude 19 East.

14. As the Degrees of Latitude near the Equator are too close together, to admit of distinguishing the Latitude of a Place to a single Degree, I shall add the following little Table, to supply that Defect.

* By this Problem, if the young Student is desirous of having any Place inserted which is not already on the Instrument, it is readily done.

In the Northern Hemisphere.		Southern Hemisphere.	
		Admiralty Isles	5 S
Barbudos	9 $\frac{1}{2}$ N.	Angola	7
Benin	7	Ascension grand	
Borneo (middle)		Isle	8
Isle	2	Borneo Isle	
N. Point of dit.	7 $\frac{1}{2}$	(middle)	0
Carolines new	10	Dit. South Pnt.	4
Ceylon Isle	7 $\frac{1}{2}$	Gallopegos Isle	
Gallopegos Isles		(middle)	0
(middle)	0	Dit. South Pnt.	1 $\frac{1}{2}$
Northernmost		Jaya Isle	8
ditto	1 $\frac{1}{2}$	Lima	11
Panama	9	St. Mathew's	
Porto Bello	9 $\frac{1}{2}$	Isle	2
Sumatra Isles		St. Thomas's	
(middle)	0	Isle	1
N. Point of ditto	6	Solitary Isle	11
Surinam	6 $\frac{1}{2}$	Solomon Isle	11
		Sumatra (mid-	
		dle)	0
		Dit. South Pnt.	6

15. PROBLEM III. *To find all those Places of the same Latitude as a given Place.*

Bring the given Place to the General Meridian, and observe the Degree of Latitude; then turn the circular Plate about, and all those Places that pass under the same Degree have the same Latitude.

16. PROBLEM IV. *To find all those Places of the same Longitude as a given Place.*

Bring the given Place, to the General Meridian, then all Places under that Meridian have the same Longitude.—Otherwise, lay the String over the given Place, and the Places which lie under it will be those required.

17. PROBLEM V. *By having the Longitude of any Place, according to the English Method, to find its Longitude according to the French Method.*

Bring the French Meridian (which lies $17^{\circ} \frac{1}{2}$ W. of London, and passes through Ferro) to the General Meridian,

Meridian, then laying the String over the given Place, or its Longitude on the Equator, it will cut on the outermost Circle of the upper Plate, the Longitude from Ferro, which is always East, according to the Custom of the French.

EXAMPLE. Suppose looking into an English Gazetteer, or on the Northern Hemisphere, I find Jamaica is in Longitude 78° West, and want to find it on a French Map, which counts the Longitude from Ferro. *Quere*, What Longitude must I look for on the French Map?

ANSWER. In the Longitude 300° East.

18. PROBLEM VI. *To change Longitude according to the French Method, to Longitude according to the English Method.*

This being only the last Problem inverted, the Reverse of the last Example will serve as an Example for this.

19. PROBLEM VII. *To find the Difference of Latitude between any two Places; that is, how much the Parallel of Latitude of one Place is to the Northward or Southward of the Parallel of Latitude of the other given Place.*

Bring each Place to the General Meridian, and observe its Latitude, and the Degrees between these two Latitudes is the Difference of Latitude required. Hence it appears, that if the Places are both in North Latitude, or both in South Latitude their Difference; but, if one is in North Latitude, and the other in South, their Sum will give what is called * (but improperly) the Difference of Latitude of those Places.

EXAMPLE. What is the Difference of Latitude between London and Paris.

ANSWER. Three Degrees.

20 SCHOLIUM. In like Manner according to the English Method of counting Longitude, if both Places

* See Difference of Latitude and Difference of Longitude in our Epitome of Philosophy, Geography, and Astronomy.

Places are in East Longitude, or both in West Longitude, subtract the lesser Longitude from the greater the Remainder will be the Difference of Longitude required: But if one is in East Longitude and the other in West, we must add them together and their Sum if it exceeds not 180 Degrees is called the Difference of Longitude; if more than 180 Degrees subtract from 360 Degrees.

21. PROBLEM VIII. *To find the Place whose Inhabitants are called * Antoekei, with Respect to any given Place.*

Find the Latitude and Longitude of the given Place, then find on the other Hemisphere a Place in the same Longitude and the same Number of Degrees of Latitude and that will be the Place required: Thus, for Example, the Antoekei to London falls in the Great South Sea, in Latitude $51^{\circ} \frac{1}{2}$ South, and Longitude 0 Degrees.

22. PROBLEM IX. *To find the Place whose Inhabitants are called Perioeki, with Respect to a given Place.*

Bring the given Place to the General Meridian and observe its Latitude; then will the Place which lies in the same Latitude under the opposite Meridian be the Place required.

Thus, for Example, it will be found that some Islands near Mount St. John (in the Westernmost Part of North America) are Perioeki to London.

23. PROBLEM X. *To find the Antipodes to any given Place*

Find the Latitude and Longitude of the given Place; then on the other Hemisphere bring that Longitude to the General Meridian, and under the Degree of Latitude above found, on the opposite Meridian, will be the Place required.*

Thus for Example. The Antipodes to London falls in the Great South Sea $51^{\circ} \frac{1}{2}$ S. Latitude and Longitude 180^d.

24.

* If the Reader is not acquainted with the Terms Antoekei, Perioeki, and Antipodes, he will find them explained in the Epitome of Philosophy, &c &c. — P. 50.

24. PROBLEM XI. *To find all those Places where it is Noon at any given Hour at any Place.*

Bring the given Place to the general Meridian, then lay the String to the given Hour, and it is Noon to all Places under it, they having the same Longitude.

EXAMPLE. Thus, when it is $\frac{1}{2}$ after 5 in the Evening at London, at what Places is it Noon?—

Answer. To all Places in $82^{\text{d}} \frac{1}{2}$ West Longitude; hence it is Noon at that Time at Hudson's Bay, Part of Virginia, Georgia, Cuba, Porto Bello, Panama, &c. in the Northern, and to Lima and Cape Horn in the Southern Hemisphere.

24. PROBLEM XII. *When it is Noon at any given Place to find what Hour it is at any other given Place.*

Bring the Place where the Time is required to the General Meridian, then laying the String over the Place where it is Noon, it will shew the Time required on the Hour Circle.—

Note, If the Place where it is Noon be London, the Meridian will serve instead of the String, to shew the Time on the Hour Circle.

EXAMPLE. When it is Noon at London it is $6^{\text{h}} \frac{3}{4}$ in the Morning at Jamaica.

25. PROBLEM XIII. *For any Hour of the Day at any given Place, to find the Hour of the Day at any other Place.*

Bring the Place where the Time is given to the General Meridian and observe what Degree of Longitude corresponds to the given Hour; then turn the circular Plate about 'till the other Place whose Time is required comes to the General Meridian, then the Longitude above found will point out the Time required on the Circle of Hours.

EXAMPLE. When it is 8 at Night at London it is $3^{\text{h}} 52$ in the Morning at Pekin in China.

26. PROBLEM XIV. *The Day of the Month being given to find the Sun's Declination, that is how many Degrees the Sun is to the Northward or Southward of the Equinoctial.*

This

This is seen by Inspection only, on the little Tables for that Purpose, in the upper Corners of the large Plates.

EXAMPLE. On the 3d of June the Sun's Declination is $22^{\text{d}} \frac{1}{2}$ North.

27. PROBLEM XV. *By the Sun's Declination to find the Day of the Month.*

This being only the Reverse of the last, requires no particular Directions.

28. PROBLEM XVI. *To find all those Places the Sun will be vertical to, on a given Day.*

Find the Sun's Declination, then all the Places whose Latitude is equal to the Sun's Declination, and of the same Name, will have the Sun directly over Head that Day. Therefore turn the circular Plate about, and observe the Places which pass under that Latitude on the General Meridian, and they will be those required.

N. B. See the Latitude of Places near the Equator in Problem 2d.

EXAMPLE. Thus it will be found that on the 9th of May and 3d of August, the Sun passes directly over Head to Jamaica, &c.

29. PROBLEM XVII. *To find what Day the Sun will be vertical to a given Place in the Torrid Zone.*

Find the Latitude of the Place, then observe in the Tables of Declination what Days the Sun's Declination is equal to the Latitude and of the same Name, for they are those required.

The Reverse of the last Example will serve as an Example for this Problem.

30. PROBLEM XVIII. *To find the Place where the Sun is Vertical when it is any given Hour at a given Place.*

EXAMPLE. On June 3, when it is seven o'Clock in the Morning, at London let it be required to find where the Sun is Vertical.

The Sun's Declination that Day is $22^{\text{d}} \frac{1}{2}$ North therefore the Place must be in $22^{\text{d}} \frac{1}{2}$ North Latitude. Bring the given Place (in our Example London) to the

the General Meridian; observe what Degree of Longitude corresponds to the given Hour, (in this Example, it will be found to be 75^{d} East) then bring that Degree of Longitude to the General Meridian, and under the Degree of Latitude, which is equal to the Sun's Declination, and is of the same Name, we shall find the Place required. In our Example it falls in Mogul India, in Latitude $22^{\text{d}} \frac{1}{2}$ North, and Longitude 75^{d} East.

31. PROBLEM XIX. *To find what Places can see a Transit of Venus and Mercury.*

Find where the Sun is Vertical by the last Problem, then all the Places that are not more than 90^{d} Degrees distant from that Place, will have the Sun above their Horizon, and consequently, if there is a Transit, may (if fair Weather) be seen.

But whether the Transit of Venus and Mercury, or Eclipses of the Sun and Moon, or Occultation of the Stars, may be seen at any particular Place, is better done on the Analemma, by which may easily be found the Time of the Sun's, Star's, Planet's, or Moon's rising, southing or setting, or Height above, or Depression, under the Horizon for any Time, and consequently, whether the Object be visible or not.

32. PROBLEM XX. *To find how many Miles make a Degree of Longitude in any Latitude, or in other Words how many Miles a Ship must sail on an East or West Course in any Latitude to alter one Degree of Longitude.*

For this and like Purposes, on each circular Plate, one Meridian is graduated into Degrees, and is named in the following Solutions the *Graduated Meridian*.

Take from the Scale 60, which may now be called 60 Miles, then placing one Leg of the Compasses in 0 Degree of Latitude on the Graduated Meridian move the Plate about till the other Leg of the Compasses touches the General Meridian in 0 Degree of Latitude: Keep the Plates in this Situation; then extend the Compasses from the given Latitude on the Graduated Meridian to the
same

same Latitude on^d the General Meridian, then will this Extent of the Compasses, shew on the Scale, the Miles required.

EXAMPLE. In Latitude of 60 Degrees, it will be found that 30 Miles, make a Degree of Longitude; or that a Ship sailing on that Parallel, for every 30 Miles Distance, will alter one Degree of Longitude.

33. PROBLEM XXI. *To find the Course and Distance from one given Place to another.*

This admits of Three Cases.

CASE I. If the two Places are North and South of each other, their Difference of Latitude is their Distance, and therefore found as in Problem 7.

CASE II. When the two Places are both in the same Latitude.

The Course is then East or West, and their Distance may thus be found. Take the Number expressing their Difference of Longitude from the Scale, apply one End of the Compasses to 0 Degree of Latitude on the Graduated Meridian, and then turn the circular Plate, till the other Point of the Compasses fall on the 0 Degree of Latitude on the General Meridian: Keep the Plates in this Position, and then extend the Compasses from the given Latitude on the Graduated Meridian, to the same Latitude on the General Meridian, and this Extent being laid on the Scale, will give the Distance required.

EXAMPLE. What is the Distance from the Land's End of England, to the North Part of Newfoundland.

ANSWER 32 Degrees, which multiplied by 20, gives 640 Leagues.

CASE III. When the Places differ, both in Latitude and Longitude,

For the more readily seeing the Course from the Land's End of England, to any Place in the Western Ocean, I have laid down Curvilinear Lines, being Rhumbs. by which the Course is known by Inspection.

The

The Distance between Places may be found thus: Take a middle Latitude between the Latitudes of the two given Places, and with the Difference of Longitude, and this middle Latitude, find a Distance as in Case 2d, which Distance we shall call the Departure. Lay this Departure on the Scale from C. towards A, and note the Degree it falls on; then find the Number, expressing the Difference of Latitude of those two Places on the Scale C. B. Then extend the Compasses from the Difference of Latitude on the Scale C. B. to the Departure on the Scale C. A, and that Extent measured on the Scale will shew the required Distance. And if a Ruler or String be laid from the Place whereon the Point of the Compasses rested on C. B, viz. to the Place it rested on C. A, as suppose on *b*, *a*, then does the Direction of that Line, or the Angle *a b C*, shew how much the Course is from the North or South, towards the East or West; and may be easily seen, by observing which Point of the Sea Compass is parallel to that Line.

EXAMPLE. What is Course and Distance from the Land's End of England to Jamaica.

ANSWER. The Course is about 5 Points and a Half from South towards the West, or S W b W $\frac{1}{2}$ W, and Distance 68 Degrees, which multiplied by 20, gives 1360 Leagues.

More Problems might have been added, but these are sufficient to shew that the Panorganon and Analemma, will be useful to young Students in Geography and Navigation.

F I N I S.



A
-
i
-
e
c
r
at
it
e
v
n,
n,
a-
he
alf
W,
eo,
ese
na-
ra-